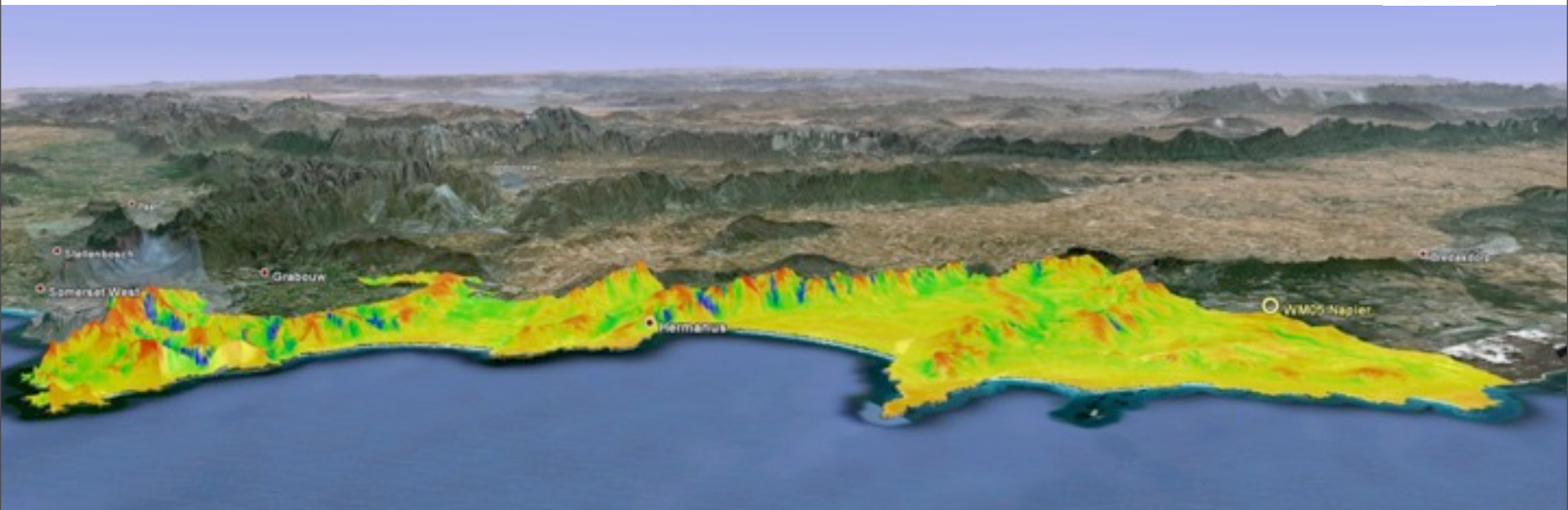


Work Package 1 - Mesoscale modelling

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On behalf of the WASA project team



Acknowledgements

The Wind Atlas for South Africa (WASA) project is an initiative of the South African Government - Department of Minerals and Energy (now DoE) and the project is co-funded by

- UNDP-GEF through the South African Wind Energy Programme (SAWEP)
- Royal Danish Embassy

South African National Energy Development Institute (SANEDI) is the Executing Partner coordinating and contracting contributions from the implementing partners:

CSIR, UCT, SAWS, and Risø DTU.



energy
Department:
Energy
REPUBLIC OF SOUTH AFRICA



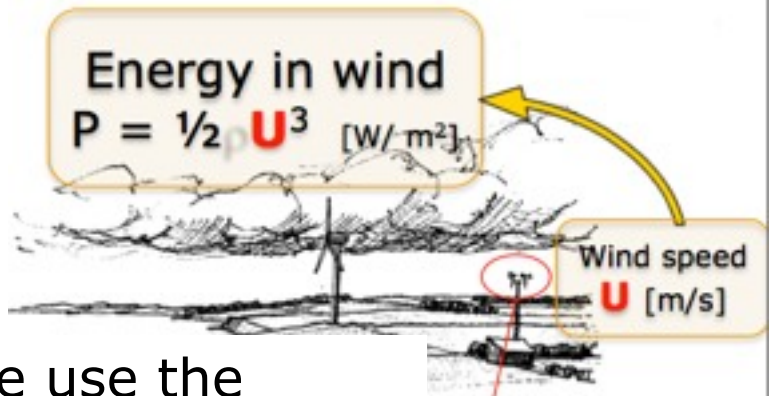
Assessing Wind Resources

Determining accurately the wind resource is critical:

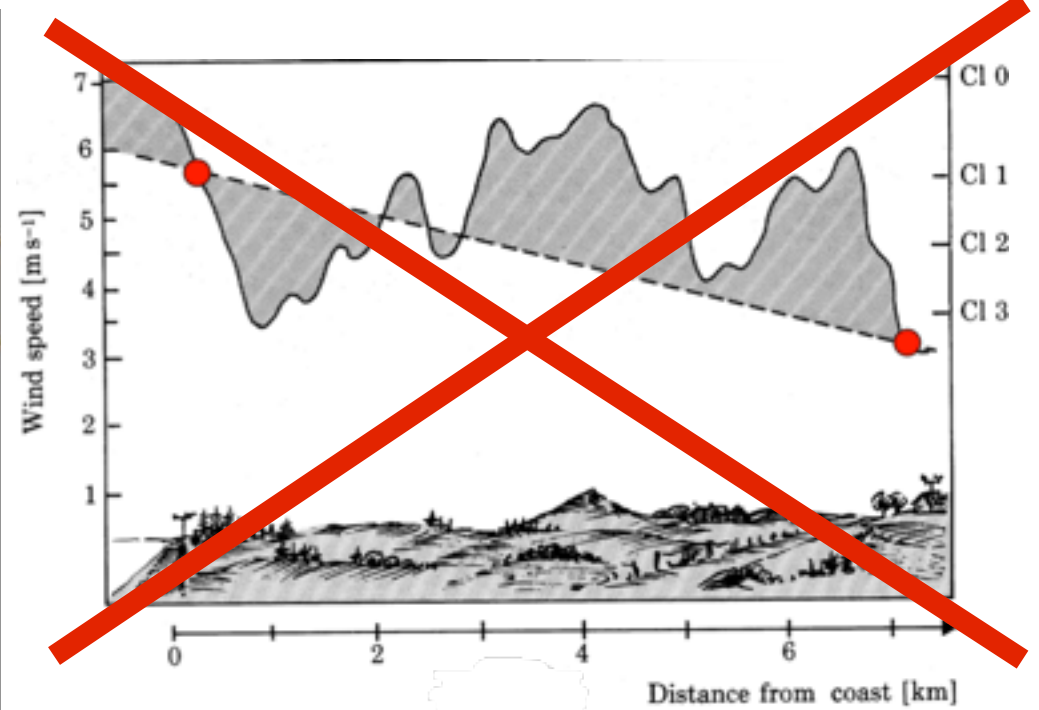
Wind resources

- Wind speed, U [m/s]
- Kinetic Energy flux, $P = \frac{1}{2}\rho U^3$ [W/ m²]

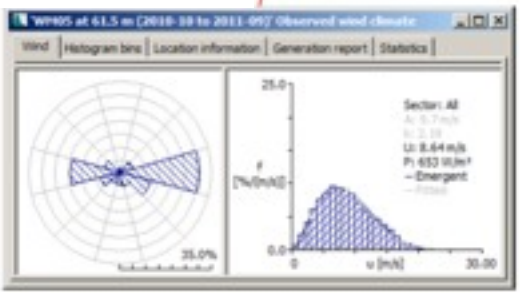
• ΔU of 10% (e.g. $U=10.0\pm 1\text{m/s}$) \longrightarrow **ΔP of 30%**



We use the measuring station to assess energy in the wind

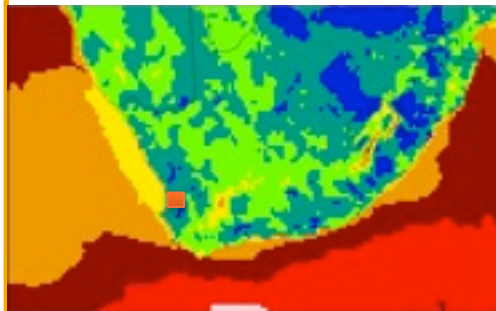


**Determine the wind resource:
We use models**

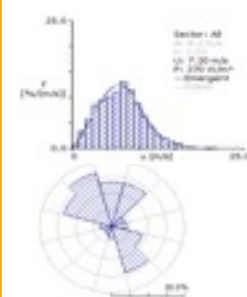


Wind Atlas South Africa

Regional wind climate



WP5: Extreme wind climate (SAWS)



WP2: Measurements (CSIR)

wind farm

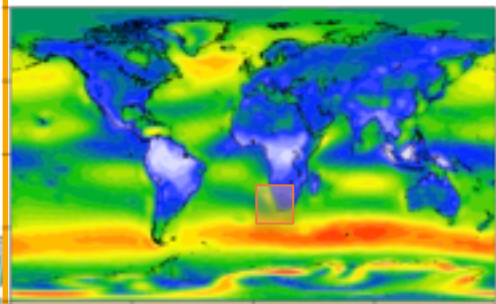


WP1: Meso-scale modelling (CSAG)

WP6: Documentation & dissemination (SANEDI)

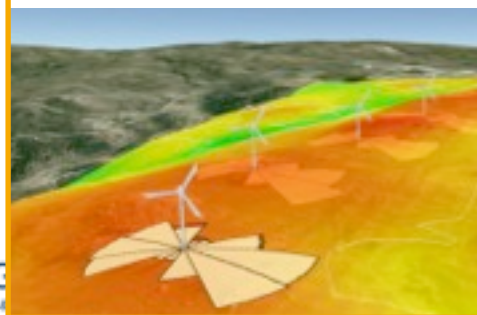
WP3: Micro-scale modelling (CSIR)

Global



WP4: Application for wind resource assessment (CSIR)

Local wind

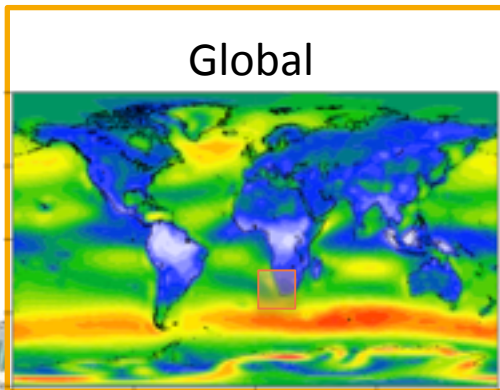


Wind Atlas South Africa

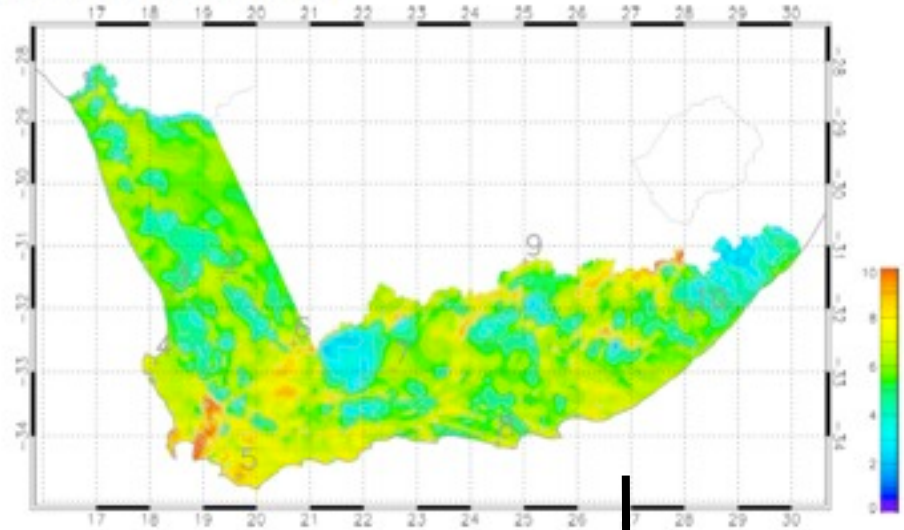
WP1: Meso-scale modelling

Downscaling
1. KAMM
2. WRF

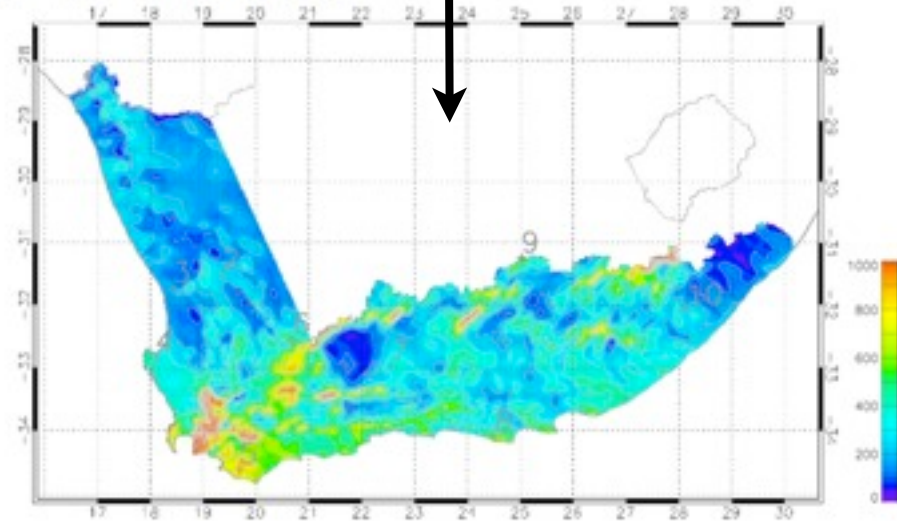
Surface Roughness
Surface topography
Observations
Reanalysis



Generalized annual mean wind speed [m/s]
(30-year climatology)

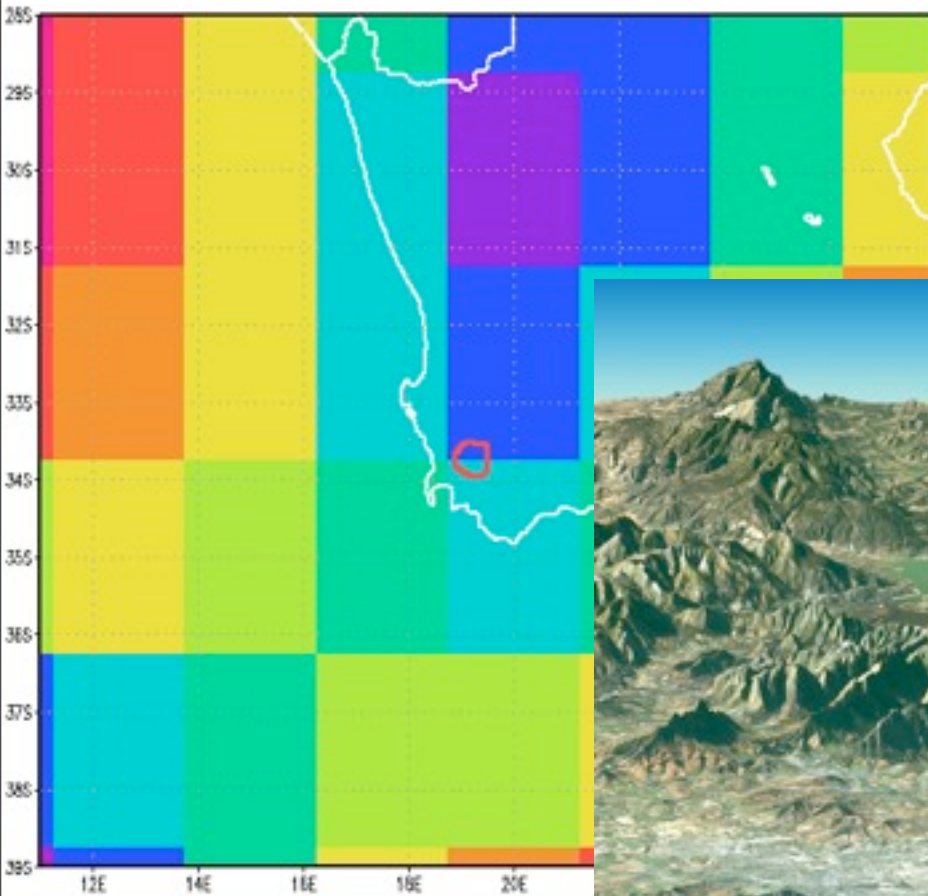


Generalized annual mean wind power density [W/m²]
(30-year climatology)



What is downscaling and why downscale..?

Global Climate Model resolution

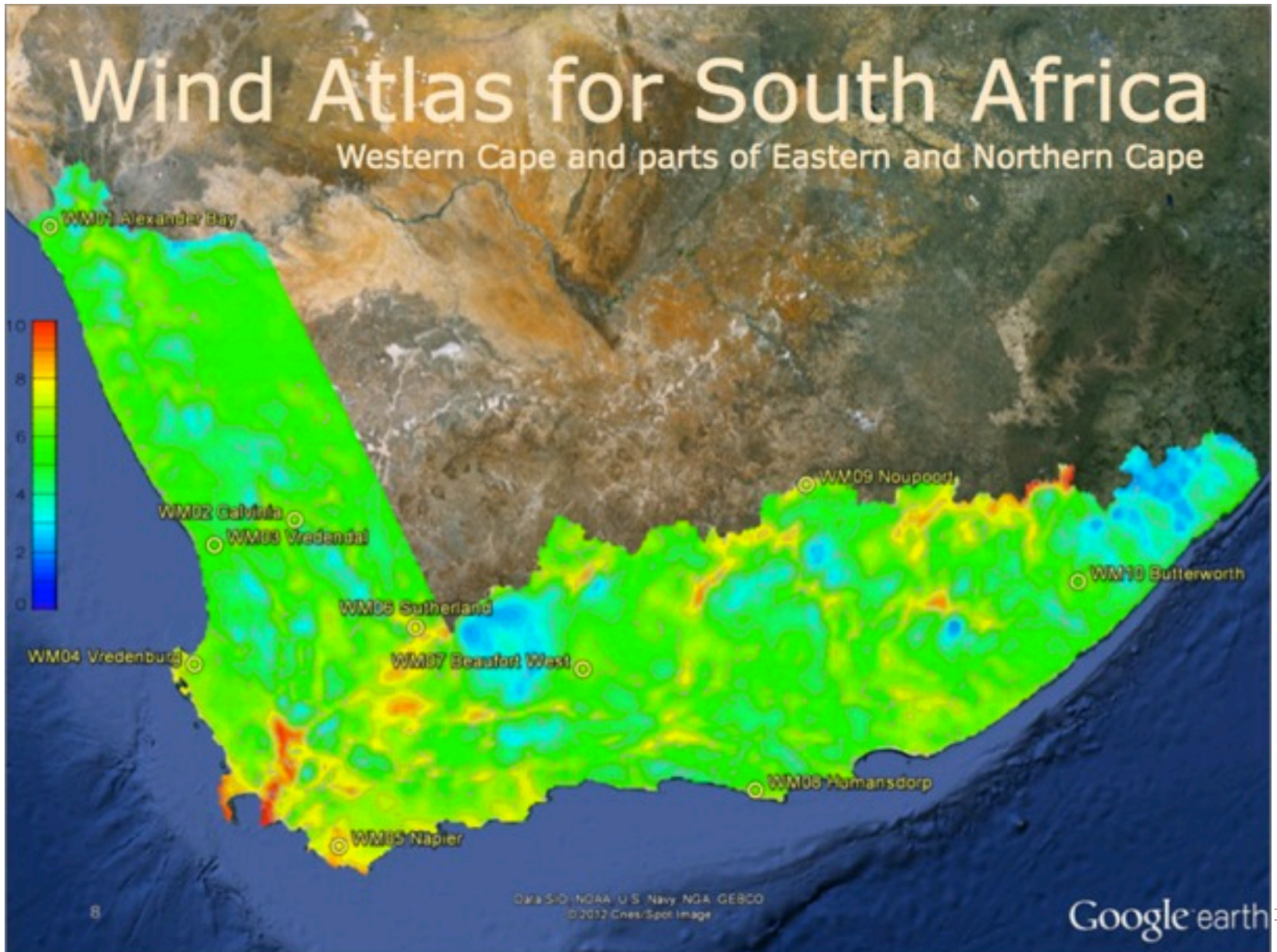


Use mesoscale models to do the downscaling:
1. KAMM

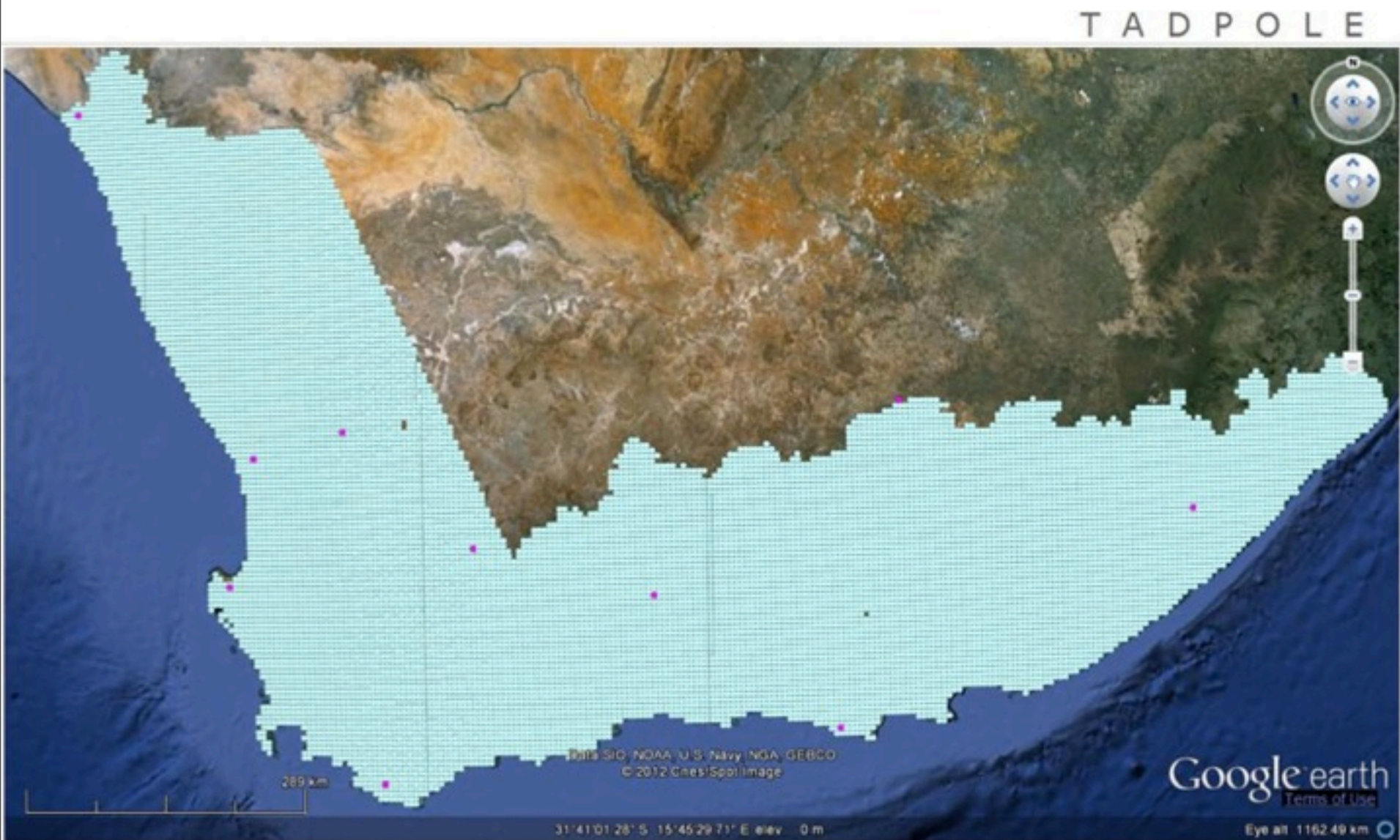
1. Downscaling with KAMM...

- “Steady-state” simulations from 100+ wind situations (initial conditions)
- Each initialized with a single vertical representation of the atmosphere
- Boundary conditions: uniform land and sea temperatures

This produces a Generalized wind climate



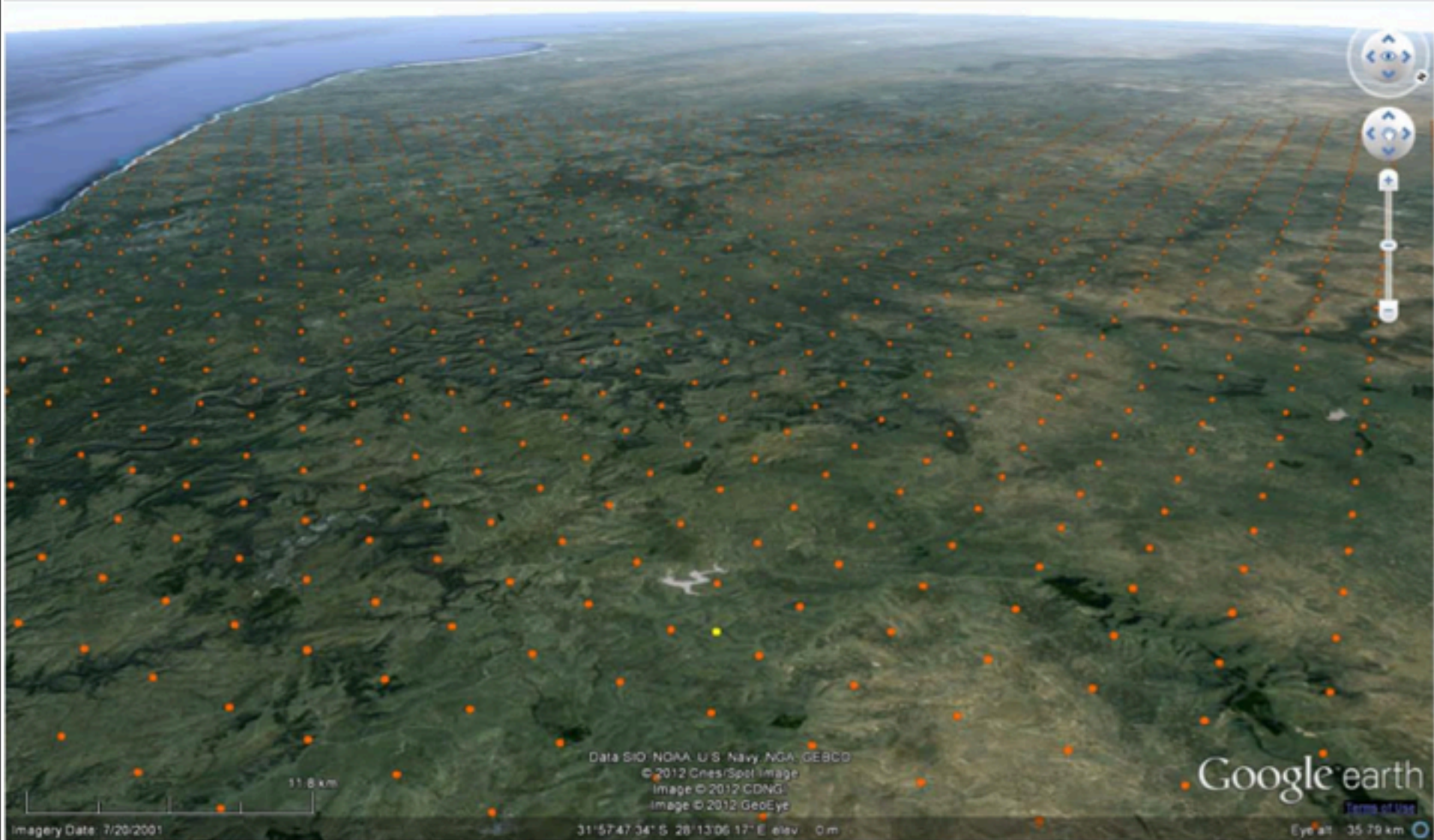
This produces a Generalized wind climate



Now we have a Wind Climate

Mesoscale results

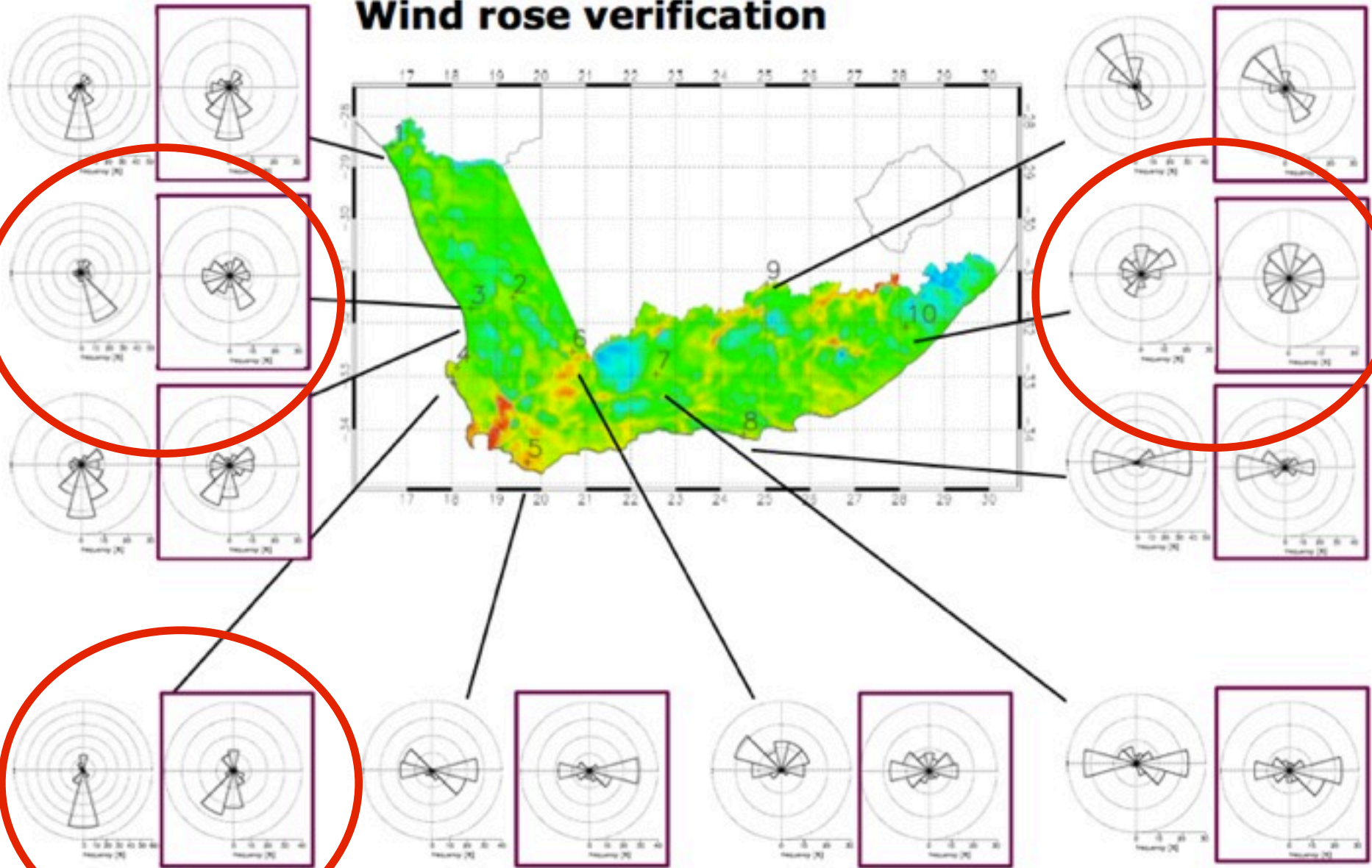
TADPOLE



Tuesday 11 December 12

Verification

Wind rose verification



Boxed wind roses derived from observation, unboxed derived from KAMM/WASP.



Verification

Wind speed verification

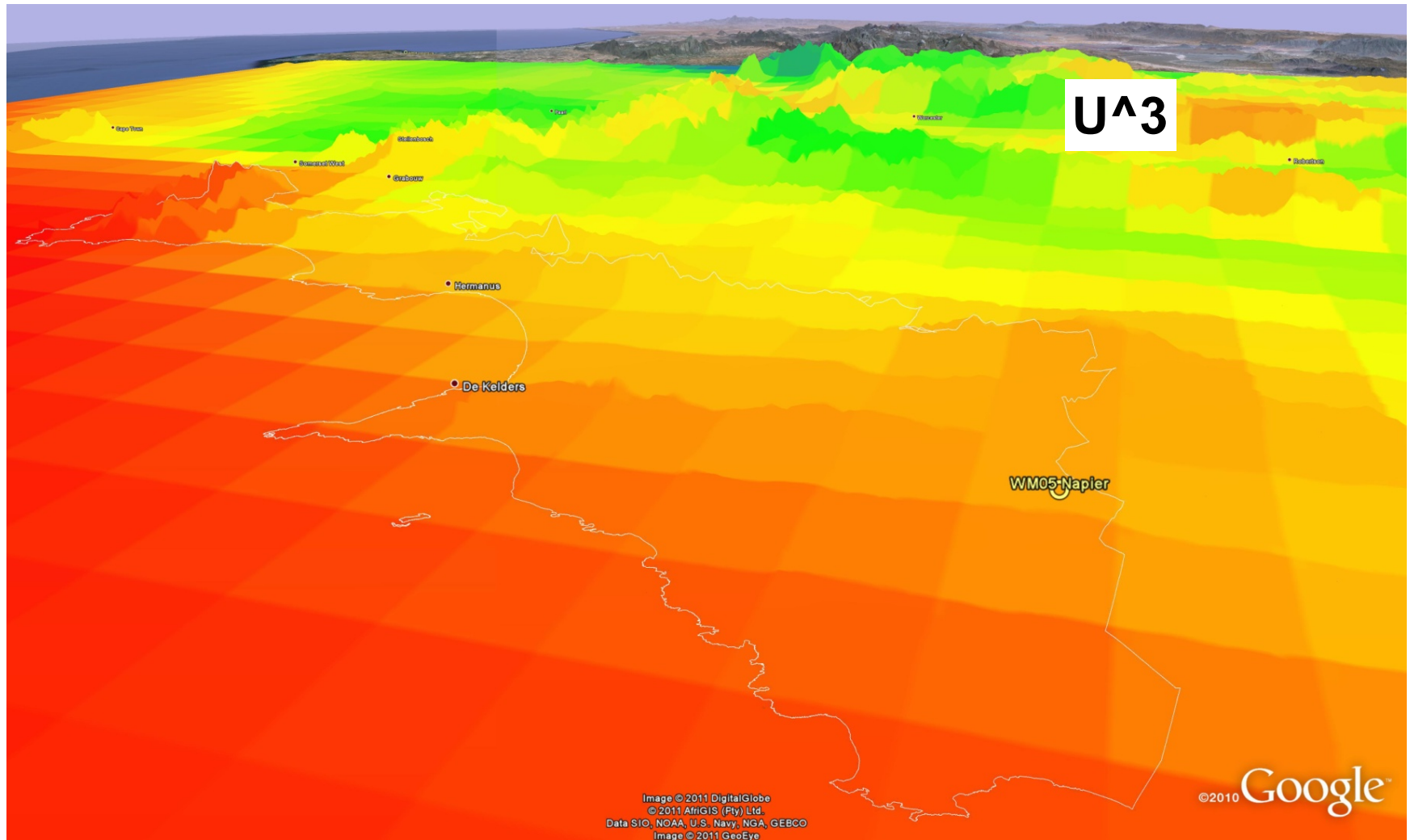
	generalized annual mean wind speed at 100 m, z0 = 3 cm [m/s]			
Met mast	OBS Wind Climate	NUM Wind Climate	Error [%]	Configuration
1	6.16	5.33	-13.47	SA5050_m7
2	6.62	7.01	5.89	SA5050_m7
3	7.19	6.63	-7.79	SA5050_m7
4	7.33	7.19	-1.91	SA2050_02
5	8.99	8.35	-7.12	SA2050_02
6	7.44	7.24	-2.69	SA2050_02
7	7.45	6.61	-11.28	SA2050_02
8	7.71	7.66	-0.65	SA2050_02
9	7.5	7.58	1.07	SA3050_03
10	6.32	6.09	-3.64	SA3050_03
		mean error	-4.16	
		mean absolute error	5.55	

Uncertainty characteristics are in line with state-of-art.

Wind Resource

Overstrand

Mesoscale and micro-scale results -> Resource Grid

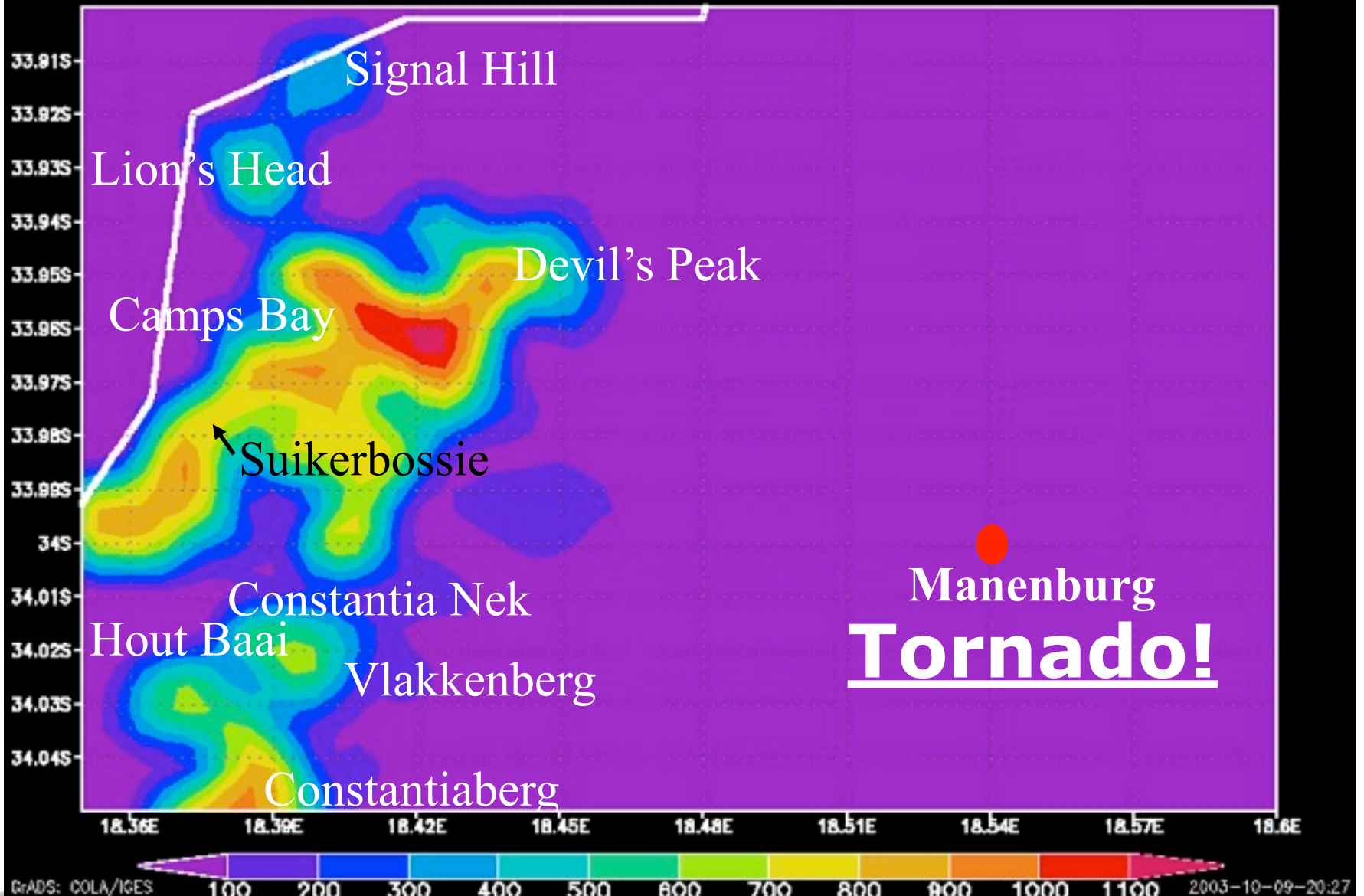


2. Downscaling with WRF...

- “Sequential” simulation that provides time-series for each grid point
- Initialized with a 3D state of the atmosphere
- Boundary conditions: interactive land + time-varying sea surface temperatures

For Example.....

Geography of Cape Town



GrADS: COLA/IGES

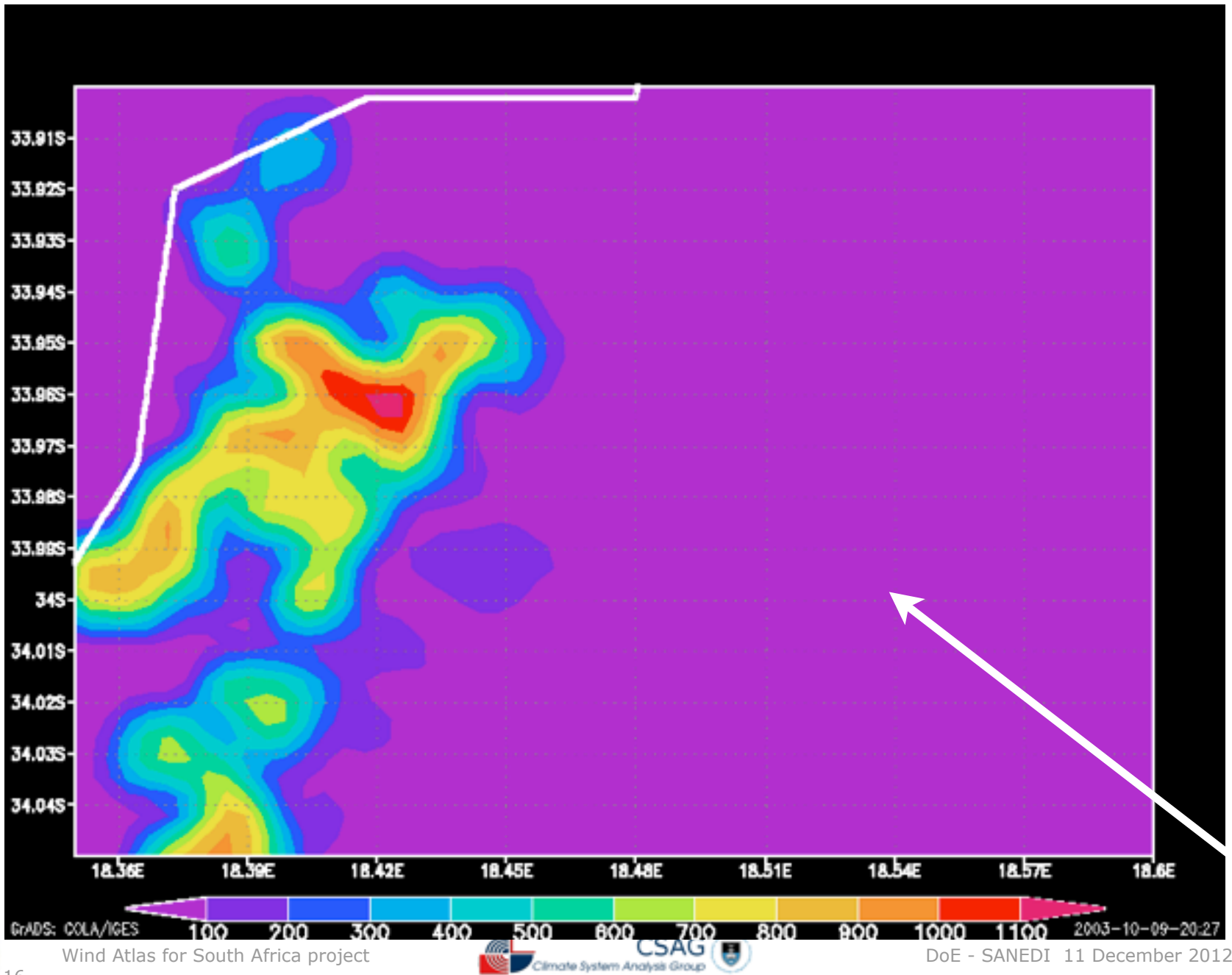
2003-10-09-20:27

Wind Atlas for South Africa project

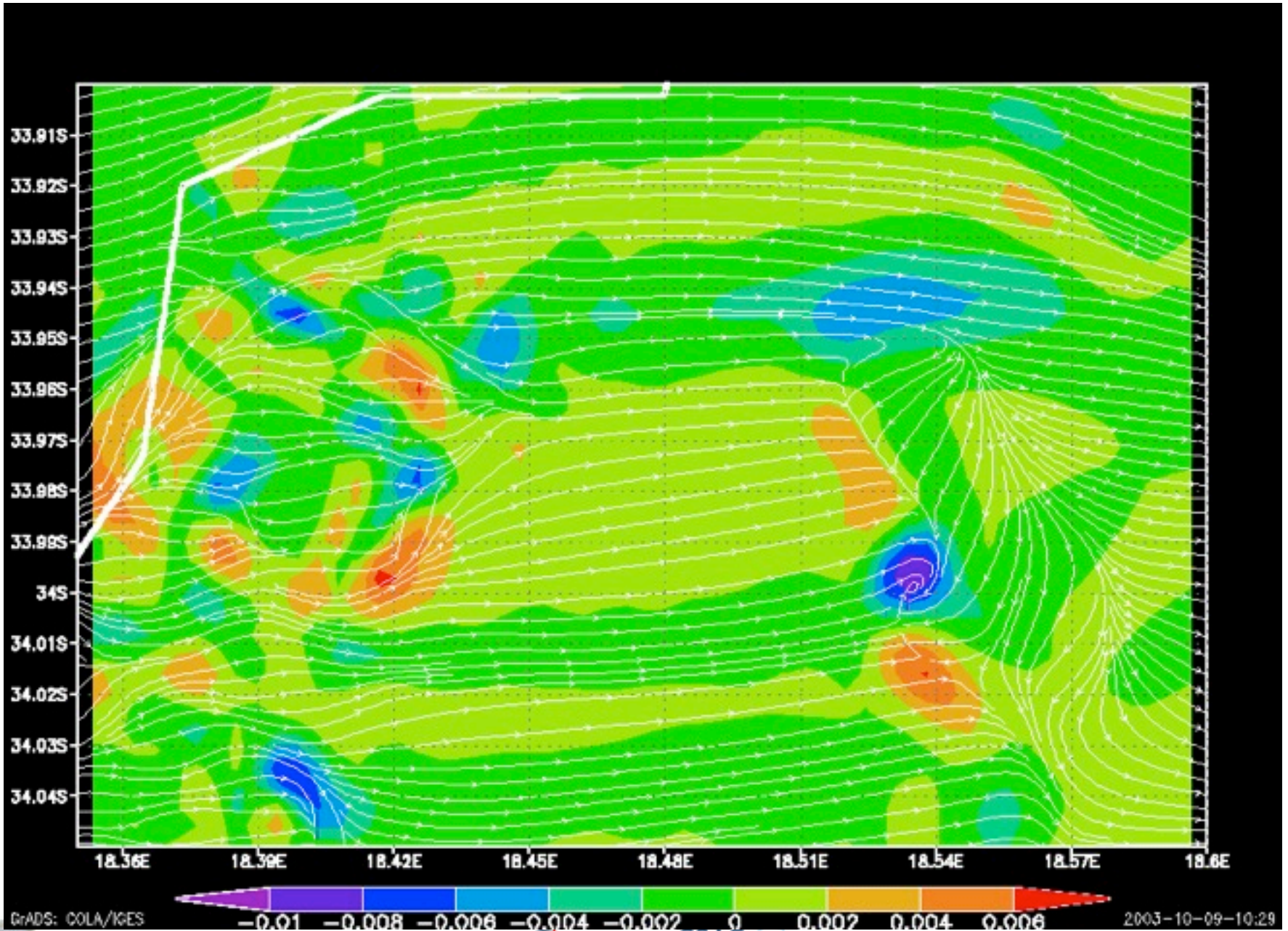


DoE - SANEDI 11 December 2012

For Example.....



Height of the vortex.....SFC



GrADS: COLA/IGES

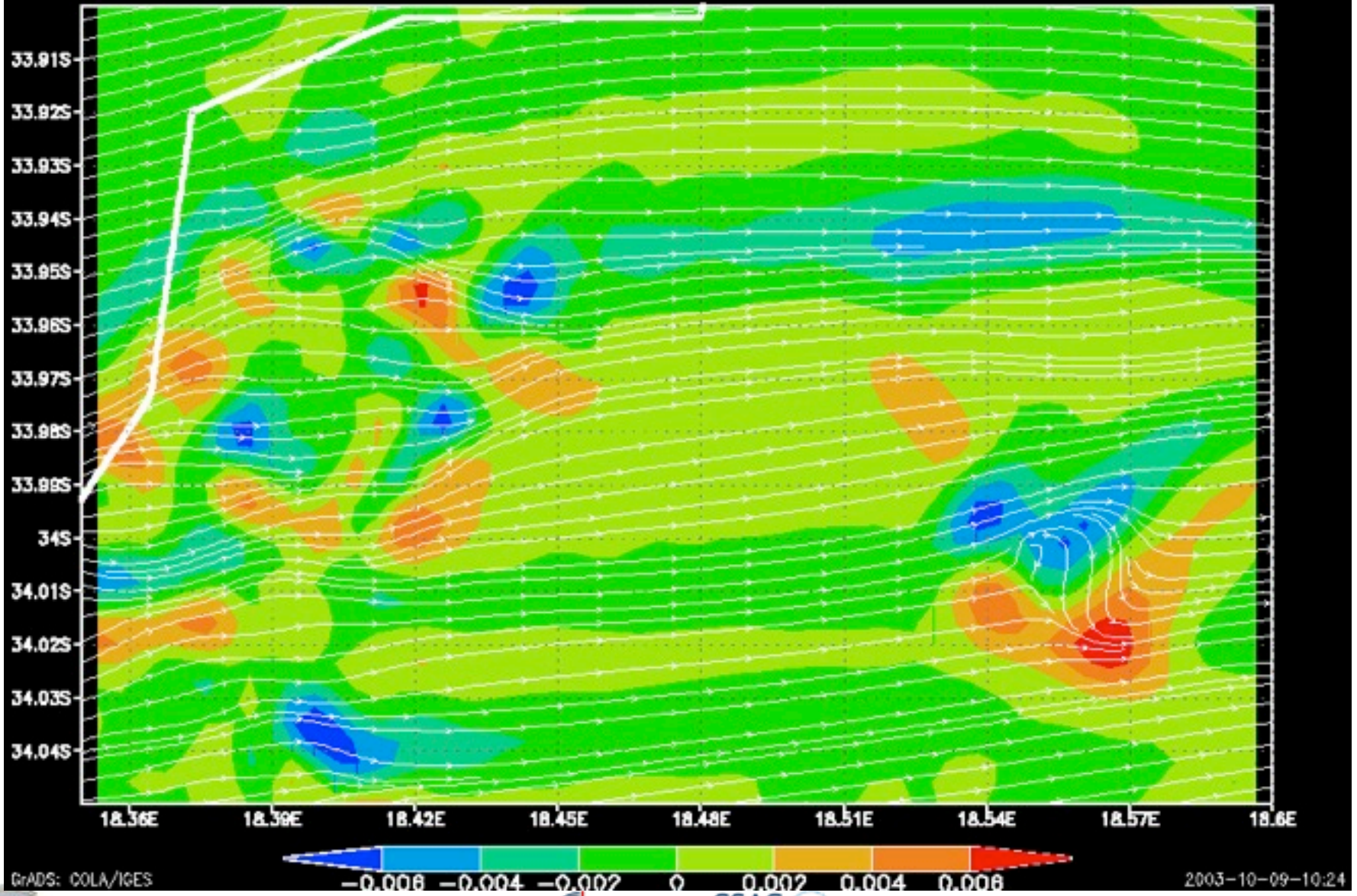
Wind Atlas for South Africa project



DoE - SANEDI 11 December 2012

Height of the vortex.....SFC

Gone at 300 meters above ground



GrADS: COLA/IGES

-0.008 -0.004 -0.002 0 0.002 0.004 0.008

2003-10-09-10:24

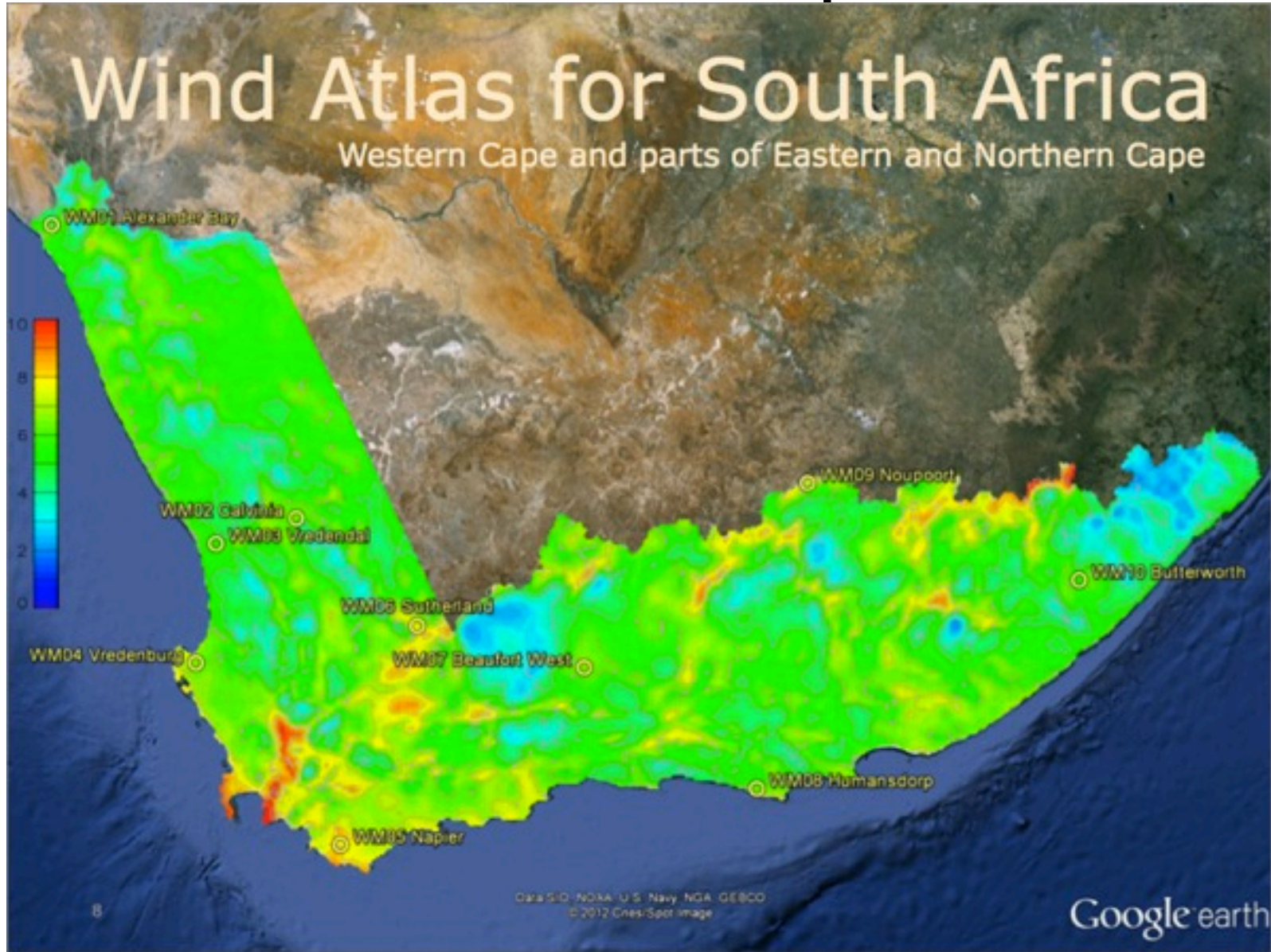


Wind Atlas for South Africa project



DoE - SANEDI 11 December 2012

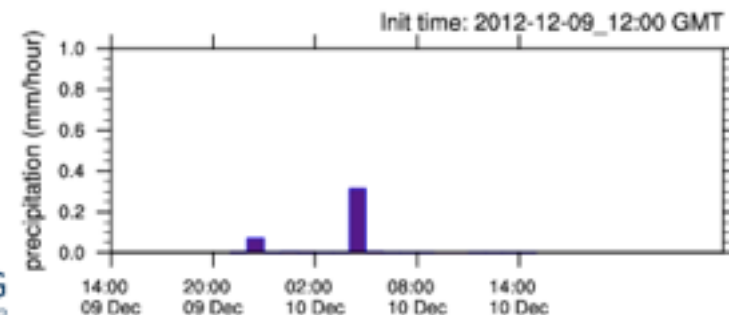
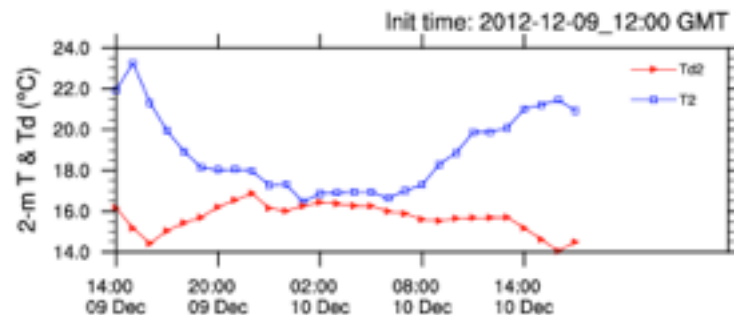
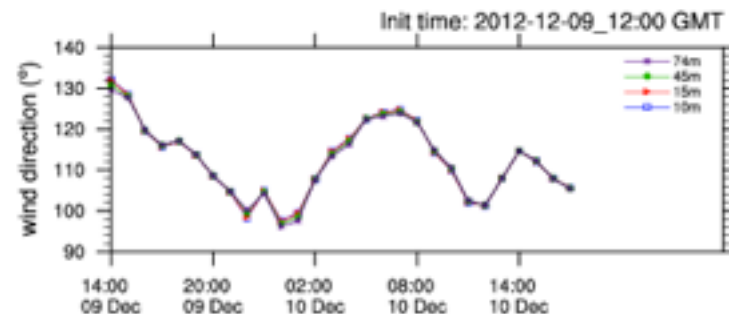
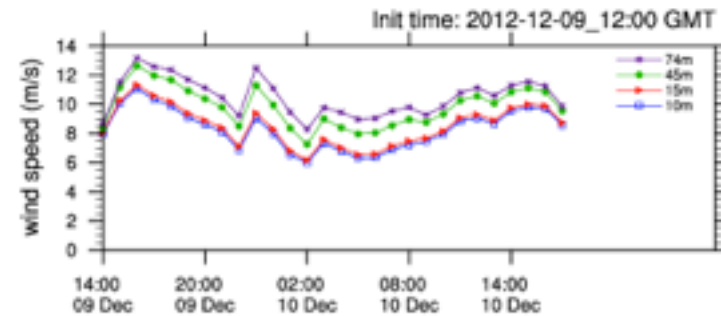
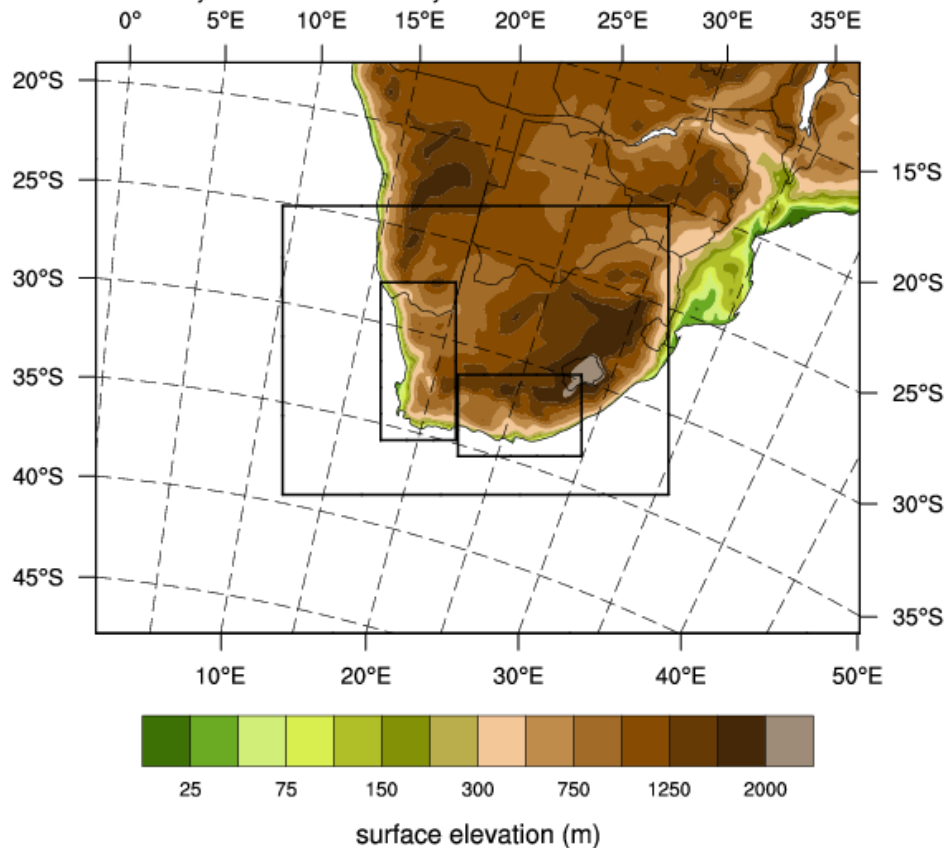
Following the same steps -> *numerical* mesoscale wind resource map



3. WASA forecast using WRF...

WM05 - Napier

WRF, DOMAIN 1, $\Delta x=27.0$ km



Two years of data

3 km resolution

<http://veaonline.risoe.dk/wasa/>



Wind Atlas for South Africa project



Preliminary WRF work...

Preliminary validation Oct 2010-Sep 2011

Comparison of measured and simulated
generalized 100 meter wind speed -
October 2010 to September 2011

	U Obs (m/s)	U WRF (m/s)	U bias (m/s)	Absolute Error
WM01	6.59	6.39	3%	3%
WM02	6.74	7.82	-16%	16%
WM03	7.32	6.99	5%	5%
WM04	7.40	7.77	-5%	5%
WM05	8.82	8.50	4%	4%
WM06	7.56	8.25	-9%	9%
WM07	7.67	7.00	9%	9%
Mean Absolute Error:				7%

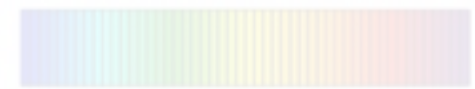
Oct 2010-Sep 2011 time-mean
wind speed (m/s) at 100 meters

Oct 2010-Sep 2011

Height: 100 meters



mean wind speed (m/s)



4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10 10.5

DTU Wind Energy, Technical University of Denmark



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Wind Atlas for South Africa project



Climate System Analysis Group

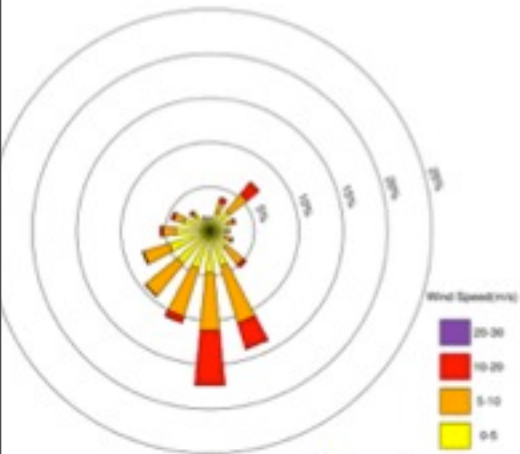


DoE - SANEDI 11 December 2012

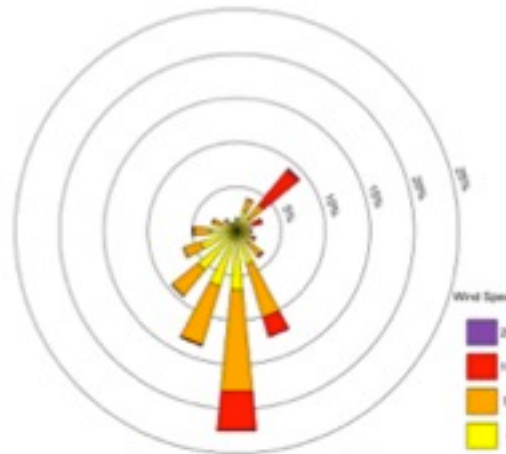
Preliminary WRF work...

Comparison of measured and simulated 62 meter winds at WM01 - Oct 2010 to Sep 2011 (1 year)

Winds at 62m - OBS

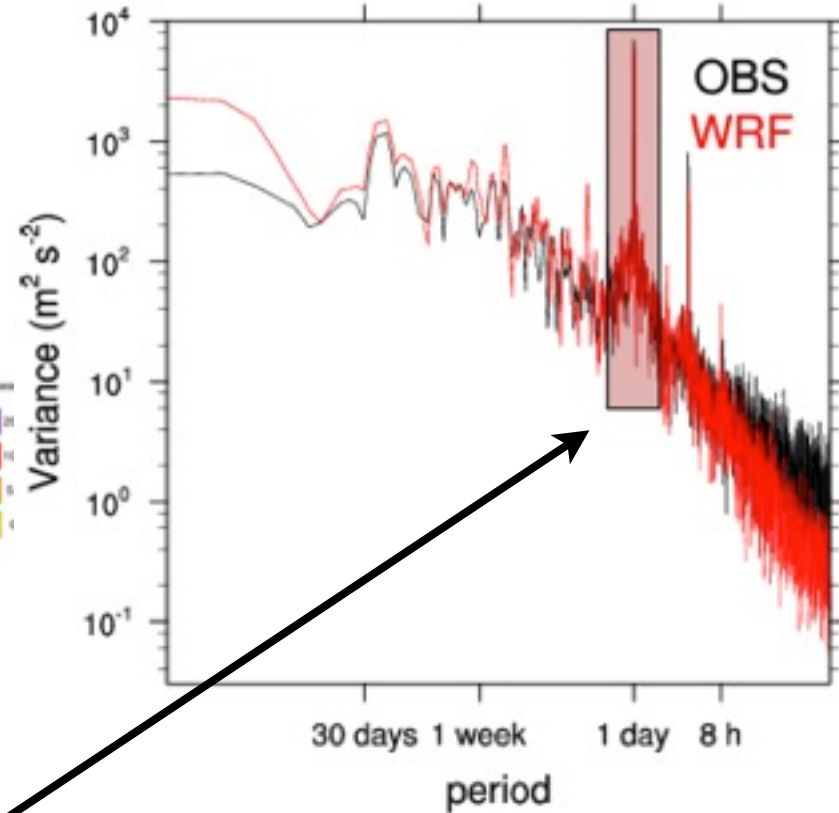


Winds at 62m - WRF



Excellent representation of the wind climatology

Wind speed - Spectra: WM01

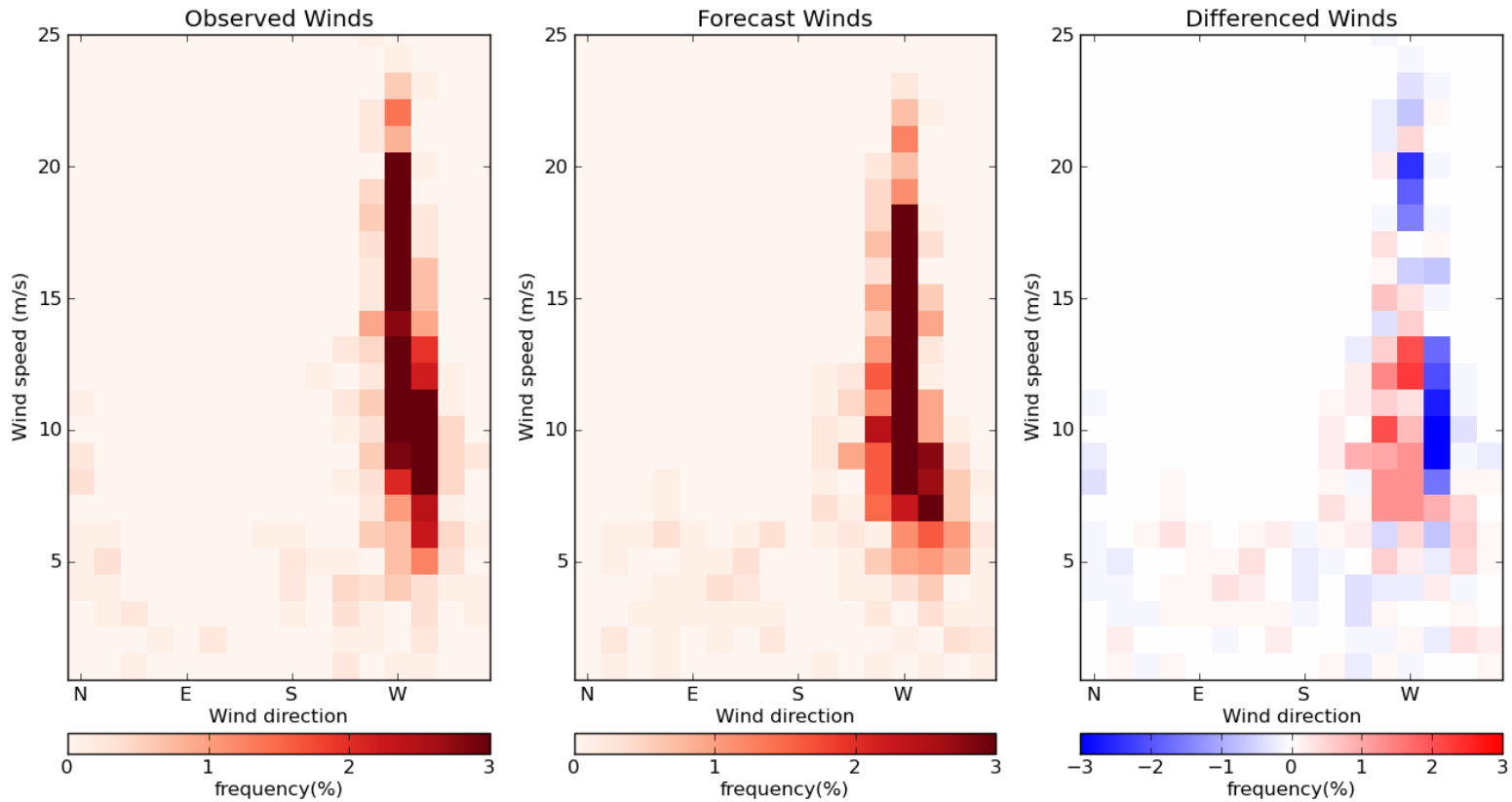


Most wind at the diurnal time scale at WM01

4. Student development.....

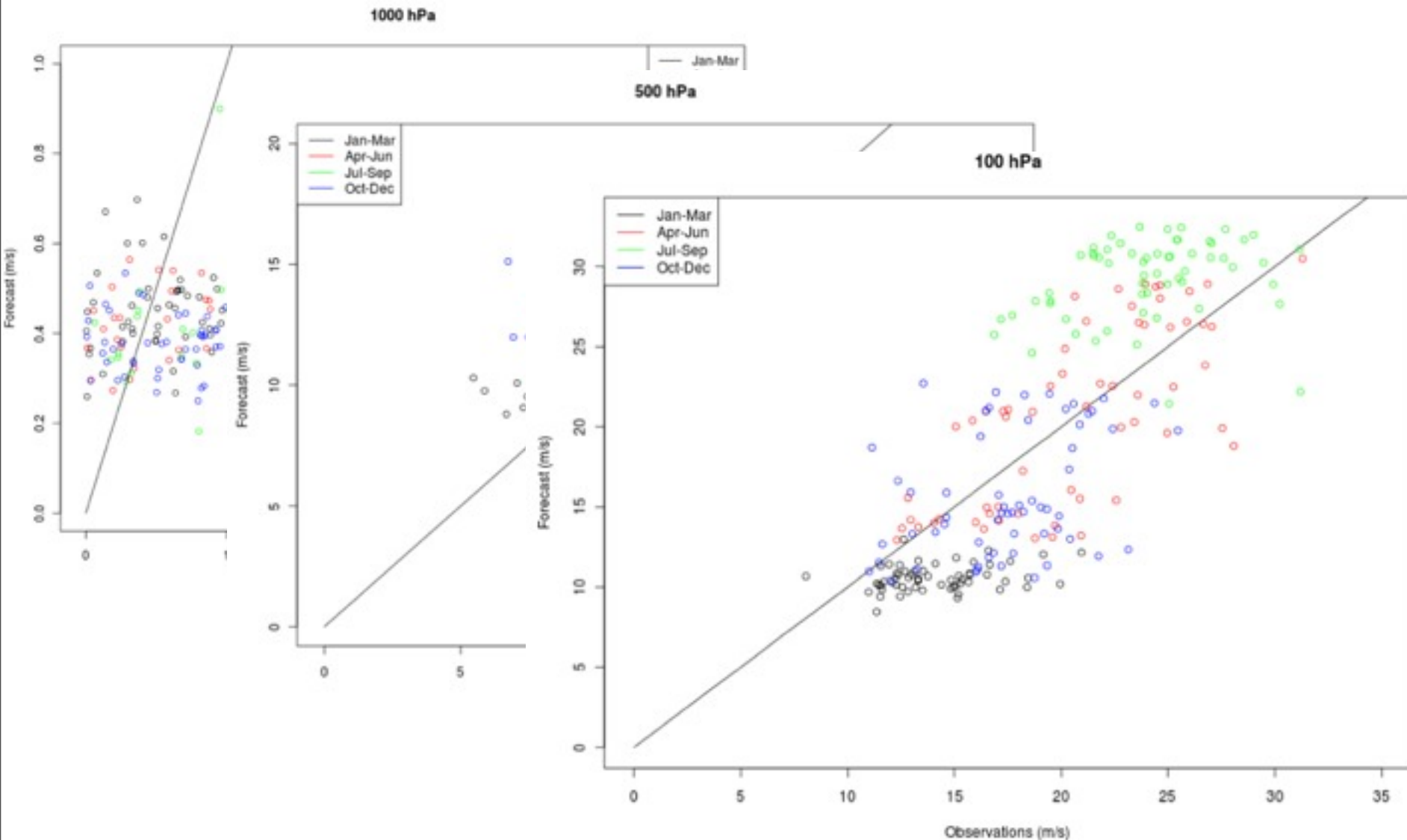
1. Verification of WRF results

2D Histograms of Observed and Forecast 60m winds at mast 8 under node 7 and the difference



4. Student development.....

2. Seasonal forecast verification

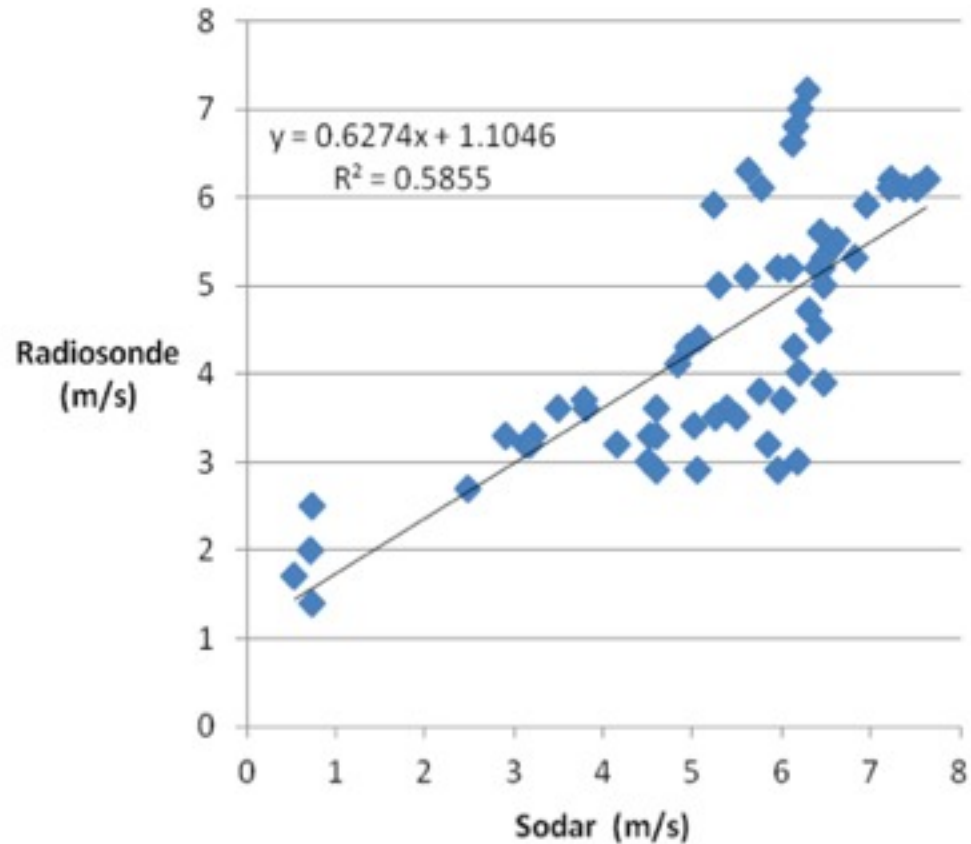


4. Student development.....

3. SODAR verification against mast and sonde data



Wind speed: Sodar against Radiosonde (all days)



Summary....WP1

1. Mesoscale Modelling

- KAMM -> First verified wind atlas for South Africa
- WRF -> Will be the first verified numerical wind atlas
- Forecast development

2. Capacity development

- First uncertainty wind atlas
- Assessment of seasonal wind forecast
- Testing SODAR

3. Future work

- Develop the optimal setup for the WRF model
- Run the 30 year simulation
- Develop the numerical wind atlas

WASA project web sites

- General information about WASA project
 - www.wasaproject.info
 - www.saneri.org.za/wind_atlas.htm
- WRF wind forecasts are available on
 - veaonline.risoe.dk/wasa
- CSIR online – display of measured data
 - www.wasa.csir.co.za
- WASA met. data download site (monthly files)
 - wasadata.csir.co.za/wasa1/WASAData
- WASA wind atlas download site **NEW!**
 - wasadata.csir.co.za/wasa1/WASAData

